(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 501 313 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **92102875.9**

(51) Int. Cl.5: **F23R 3/26**, F02C 9/40

(22) Date of filing: **20.02.92**

(30) Priority: **26.02.91 JP 30655/91**

(43) Date of publication of application:
02.09.92 Bulletin 92/36

(84) Designated Contracting States:
CH DE FR GB IT LI

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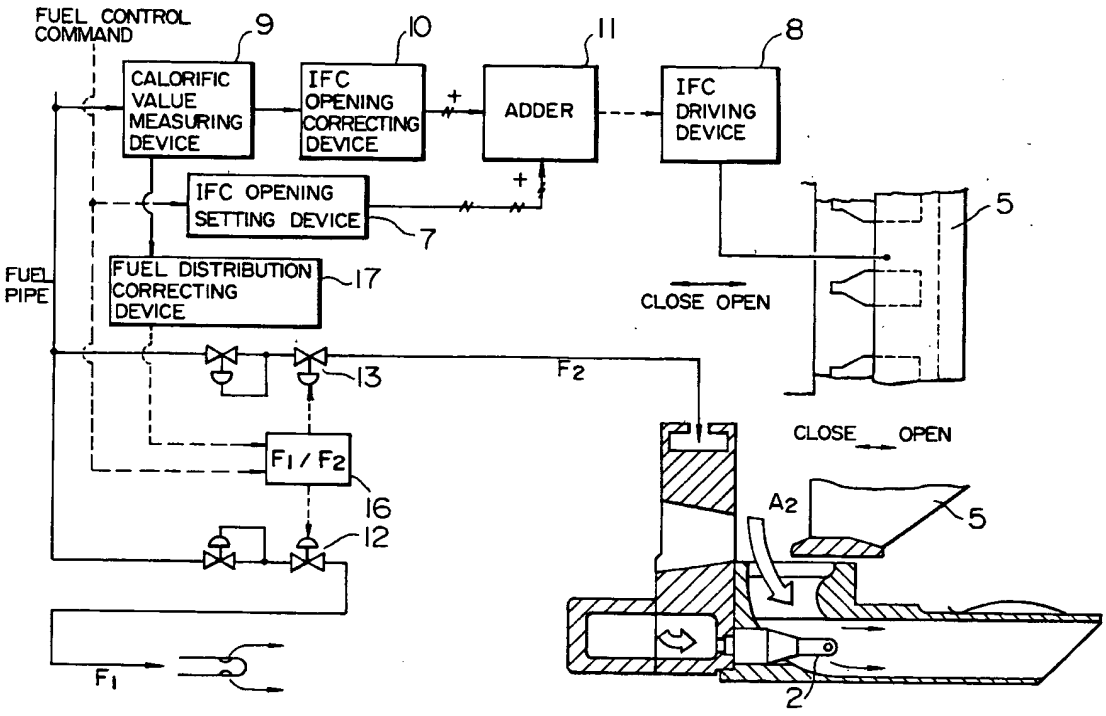
(54) Combustion apparatus and control method therefor.

(57) To provide a combustion apparatus and a controlling method therefor which are capable of preventing the flame-out and backfire of the flame of a premix burner and the increase of the NOx concentration attributable to the change of the calorific value of the fuel, the amount of air supplied to the premix burner is so controlled as to achieve a low NOx within the range in which the premix burner effects a stable combustion in accordance with the calorie of the fuel supplied to the combustion apparatus, and a change of the output of the combustion apparatus attributable to this control of the amount of air is compensated by the control of the amount of the fuel supplied to the diffusion burner.

EP 0 501 313 A1

FIG. 1


FUEL CONTROL COMMAND
9
CALORIFIC VALUE MEASURING DEVICE
10
IFC OPENING CORRECTING DEVICE
11
ADDER
8
IFC DRIVING DEVICE
IFC OPENING SETTING DEVICE
7
FUEL PIPE
FUEL DISTRIBUTION CORRECTING DEVICE
17
CLOSE OPEN
5
13
F2
F1 / F2
16
12
CLOSE OPEN
A2
5
F1
2

FIELD OF THE INVENTION

This invention relates to improvements in combustion apparatus and controlling method therefore, and particularly it relates to a combustion apparatus suitable for application to a gas turbine and comprising a premix burner and a diffusion burner.

BACKGROUND OF THE INVENTION

Conventional combustion apparatus applied generally to the gas turbine has been usually equipped with a diffusion burner C_1 at the head thereof and with a premix burner C_2 downstream of this diffusion burner as shown in Figure 2.

Thus, the burners have been combined in two stages for the purpose of obtaining a combustion apparatus capable of effecting a low NOx and stable combustion due to the diffusion combustion which achieves a high combustion stability and the premix combustion which achieves a high reduction of NOx concentration although the stable combustion range therein is narrow.

This type of two-stage combustion apparatus comprises an antechamber (diffusion combustion chamber) I, F_1 nozzles 2 for diffusion combustion, a main chamber (premix combustion chamber) 3, F_2 nozzles 4 for premix combustion, and a combustion air supply section. Particularly, in order to control the flow rate of premixed air A_2 through the F_2 nozzles 4 the stable combustion range of which is narrow, an internal flow rate control (referred to as IFC, hereinafter) 5 is provided in this combustion air supply section.

In the combustion apparatus having such construction, it has been the main current that the fuel-air ratio (the ratio of fuel amount to air amount) be controlled to be kept at a constant value by changing the air flow rate in response to the fuel flow rate determined beforehand for the operation of the gas turbine as disclosed in Japanese Patent unexamined Publication No. 60-66020 as well. Namely, the fuel flow rate is changed in accordance with the change of load and the distribution of air in the burners is also changed in accordance with the change of this fuel flow rate so as to set the fuel-to-air ratio at the predetermined value, thereby realizing the stabilization of the combustion and the reduction of the NOx.

Figure 3 shows the relationship between the fuel-air ratio and the NOx, in which the abscissa represents the fuel-air ratio and the ordinate represents the NOx relative value and which illustrates the difference between the diffusion combustion and the premix combustion. The theoretical fuel-air ratio of methane is 0.058, and gas turbine burners are usually used at fuel-air ratios smaller than 0.058. In operation, the diffusion combustion which is stable over the wide operation range is utilized from the start-up to the low-load operation of the gas turbine, and the premix combustion and the diffusion combustion are utilized simultaneously from the low-load operation to the rated-load operation, so as to reduce the NOx. On that occasion, since the range of the fuel-air ratio in which the premix combustion is effected completely (operation range of F_2) is narrow, the fuel-air ratio is set to be in the operation range by controlling the flow rate of air A_2 by the IFC 5 of Figure 2. Total combustion air A of Figure 2 is divided into a flow rate of air A_1 flowing through the antechamber 1, a flow rate of air A_2 flowing through the main chamber 3 and a flow rate of air A_3 flowing into through dilution holes 6. When the IFC 5 is opened, the amount of air A_2 is increased and the amounts of airs A_1 and A_3 are decreased, while when it is closed, the amount of air A_2 is decreased and the amounts of airs A_1 and A_3 are increased.

From the viewpoint of efficient use of energy, there arises a problem of the treatment of vaporized gas called BOG gas (boil-off gas) generated in power generation using LNG. The calorie of the BOG gas is lower than that of the LNG due to the difference in boiling points of the fuel components. If the BOG gas is not discharged to the outside periodically, the internal pressure of an LNG tank is increased to bring about damage. To cope with this, the BOG gas is treated as being mixed with the LNG in the existing circumstances. This results in a sudden change of the calorific value (calorie) in the LNG power plant. It is therefore difficult to realize the stable combustion and the reduction of the NOx by controlling the fuel flow alone in the conventional manner.

In the above-described prior art, change of the fuel flow rate due to load change has been taken into consideration, and however, change of the fuel characteristics such as the calorific value has not been taken into consideration. Therefore, in case of effecting the lean premix combustion and the two-stage combustion including the diffusion combustion and the premix combustion with the low NOx burner or the like, if the calorific value is changed during the constant fuel flow operation, flame is made unstable so as to cause a flame-out, or conversely a backfire of premix flame, increase of the NOx and the like. Further, this gives rise to a problem that if the calorific value of the supplied fuel is changed drastically during the constant fuel flow rate operation or the constant load operation, the load is changed greatly. Change of the calorific value of the fuel is the problem caused at the time of treating a low-calorie gas called BOG gas (boil-off gas), which is vaporized to above the LNG, in the LNG (liquefied natural gas) plant.

An object of the present invention is to solve the above-described problems, and further, to provide a combustion apparatus capable of dealing with various kinds of fuel.

For this reason, in order to realize a stable combustion over the wide range from no-load operation to the rated-load operation, such control as shown in Figure 4 has been performed. In this diagram, the abscissa represents the fuel command signal correspondingly to the load ranging from the no load to the rated load and the ordinate represents the flow rate of fuel through the F_1 and F_2 nozzles 2 and 4 and the opening of the IFC 5. On the lower load side, the flow rate of fuel is small and a lean combustion is effected, so that the diffusion combustion is utilized only due to the F_1 nozzles 2. The IFC 5 is fully opened to reduce the air in the antechamber 1 so that the fuel-air ratio is increased to realize the stable combustion. It is necessary to reduce the ignition load of the F_2 nozzles 4 for the purpose of expanding the range of the operation load. Therefore, by closing the IFC 5 from the point 1 to the point 2 as shown in Figure 4, the flow rate of air A_2 through the main chamber 3 is reduced so that the combustion can be effected in a stabilized manner with the fuel supplied from the F_2 nozzles 4 at the time of changing over the fuel. At that time, the flow rate of air A_1 through the antechamber 1 is increased so far as the combustion can be effected in a stabilized manner with the flow rate of the fuel flowing through the F_1 nozzles 2 at the time of the changing-over, and the load at that time is regarded as the minimum change-over load.

After the ignition at the F_2 nozzles 4, the opening of the IFC 5 is increased, as the load is increased to the rated load in due order through A → B → C, so that the flow rate of air A_2 through the main chamber 3 is increased and, at the same time, the fuel supplied from the F_2 nozzles 4 is increased, thereby setting the fuel-air ratio to be in the operation range shown in Figure 3 so as to reduce the NOx.

In controlling the fuel, the fuel command signal is sent to an IFC opening setting device 7 so as to operate an IFC driving device 8 as shown in Figure 2.

SUMMARY OF THE INVENTION

To this end, in case of distributing the diffusion combustion air and the premix combustion air, the composition or calorific value of the fuel is measured before it is supplied to the burners and the air distribution is changed so as to minimize the NOx in the premix combustion zone within the stable range, and the change of the load attributable to the change of the calorific value is controlled by the supply of the fuel to the diffusion combustion zone.

Further, in case of controlling the fuel-air ratio by making the combustion air bypass to downstream of the burner outlet, the amount of air bypassed is so set as to minimize the NOx in the premix combustion zone in accordance with the change of the calorific value, the change of the load attributable to the change of the calorific value is controlled by the supply of the fuel to the diffusion combustion zone.

The calorific value of the fuel is measured by a means or device for measuring the calorific value before the fuel flows into gas turbine burners. Further, a means or device for regulating the air flow rate distribution of the burners operates to change the distribution of air in accordance with the change of the flow rate of the design fuel so as to keep the fuel-air ratio at the design value. It is noted that the fuel is designed to be used in several conditions classified taking the calorific value as the parameter so as to control the flow rate of air to be changed in accordance with the measured calorific value while keeping the flow rate of the fuel constant.

Namely, when the calorific value is changed to be decreased from its central value, the flow of air is decreased. To the contrary, when the calorific value is changed to be increased, the flow of air is increased.

In controlling the distribution of the fuel, the same amount of the fuel as that supplied before the calorific value is changed is supplied to the premix combustion zone and the flow of the fuel supplied to the diffusion combustion zone is changed so as to increase/decrease the fuel used to correct the change of the load. When the calorific value is decreased the amount of the fuel supplied is increased, and when the calorific value is increased the amount of the fuel supplied is decreased, thereby keeping the load constant.

The foregoing and other objects, features as well as advantages of the invention will be made clearer from the description hereafter of a preferred embodiment referring to the drawings.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a diagrammatic view showing essential portions of a combustion apparatus according to a preferred embodiment of the present invention;

Figure 2 is a vertically sectional side view of a conventional combustion apparatus;

Figure 3 is a graph showing the relationship between the NOx and the fuel-air ratio of the combustion apparatus;

Figure 4 is a graph showing the relationship

between the fuel command signal and the flow rate of fuel as well as the flow rate of air in the conventional combustion apparatus;

Figure 5 is a graph showing characteristic relationship between the calorific value and the NOx contained in the combustion;

Figure 6 is a graph showing characteristic relationship between the fuel command signal and the flow rate of air in the combustion apparatus according to the preferred embodiment of the present invention;

Figure 7 is a diagram showing the relationship between the IFC opening correction amount and the calorific value signal;

Figure 8 is a block diagram for explanation of the operation of the combustion apparatus according to the preferred embodiment of the present invention;

Figure 9 is an illustration showing the relationship between the fuel-air ratio and the NOx in the combustion apparatus according to the preferred embodiment of the present invention; and

Figure 10 is an illustration showing the relationship between the power and the fuel distribution in the combustion apparatus according to the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Description will be given below of an embodiment of the present invention with reference to Figure 1.

In the present embodiment, fuel is sampled on the upstream side of an F_1 fuel control valve 12 and an F_2 fuel control valve 13 and its calorific value is measured by a calorific value measuring device 9. Deviation from the design value is sent from the measuring device 9 to an IFC opening correcting device 10. A signal from the IFC opening correcting device 10 and a signal issued from an IFC opening setting device 7 based on the fuel control command are added by an adder 11 in which the fuel signal is corrected for the calorific value. Then, an IFC driving device 8 is operated to open/close an IFC 5 so as to set the ratio of air A_2 to the fuel through F_2 fuel nozzles 2 at a target value.

On the other hand, the signal from the calorific value measuring device 9 is also sent to a fuel distribution correcting device 17 so that the flow of fuel used for correcting increase/decrease of the output attributable to the change of the calorific value is so controlled as to be distributed only to the F_1 nozzles 2 for the diffusion combustion, while the flow rate of the fuel F_2 makes no contribution to the correction for the power.

Figure 5 shows the relationship between the calorific value and the concentration of the NOx taking the IFC opening as a parameter, in which the abscissa represents the calorific value of the fuel and the ordinate represents the concentration of the NOx. In case that the calorific value is changed at the design point during the operation, if only the flow rate of the fuel is controlled as conventionally done, the calorific value reaches the premix flame blowout limit when it is not greater than the minimum value because the IFC opening is not changed, resulting in a flame-out. To the contrary, in case that the calorific value is increased, the NOx content is increased. When the calorific value is further increased to reach the maximum, it exceeds the premix flame backfire limit so as to cause a backfire, resulting in the possibility of the burnout of the F_2 nozzle 2.

According to the present invention, when the calorific value is shifted to the lower value, the IFC opening is shifted from the design IFC opening to the smaller side until it is set at A, thereby preventing the blowout. To the contrary, when the calorific value is increased, the IFC opening is shifted to the larger side until it is set at B, thereby keeping the NOx content low as well as preventing the backfire.

In Figure 6, the abscissa represents the fuel command signal and the ordinate represents the IFC opening. For the same fuel command signal, the IFC opening is increased/decreased based on the measured value of the change of the calorific value. On the lower load side, since the flow rate of the fuel is small, the amount of correction for the flow rate of air attributable to the change of the calorific value is also small. In consequence, the IFC opening is controlled to be in the range of $+K_A$ to $-K_A$ as shown at A on the abscissa of Figure 6. As the load is increased and hence the flow rate of the fuel is increased, the amount of correction for the flow of air required becomes larger even for the same change of the calorific value, and therefore, the amount of correction is increased as being in the range of $+K_B$ to $-K_B$ at B on the abscissa and in the range of $+K_C$ to $-K_C$ at C on the abscissa.

Figure 10 shows the relationship between the power and the flow rate of fuel taking the calorific value as a parameter, in which the abscissa represents the power and the ordinate represents the flow rates of fuels F_1 and F_2. When the calorific value is reduced at the time of 100% power, the power is reduced from the design point A to a point D. When it is intended to operate at constant power, it is necessary to increase the fuel by an amount corresponding to the reduction of the calorific value so as to reach a point E. According to the present invention, when this is the case, the fuel increased to control the change of the power attributable to the change of the calorific value is used for the stable F_1 diffusion combustion alone,

while for the F_2 premix combustion, only the flow rate of air is changed at once when the calorific value is changed, thereby setting the fuel-air ratio properly at which the stable and low NOx combustion can be effected. Figure 9 shows the effect of this controlling method, in which the abscissa represents the fuel-air ratio and the ordinate represents the NOx relative value. In case that the calorific value of the fuel is reduced during the operation at the design point A, since the F_1, F_2 NOx is shifted to the point D in this control, the IFC 5 of Figure 1 is changed to the close position so as to reduce the flow of air A_2 and increase the flow of air A_1. As shown in Figure 9, the F_2 premix combustion is shifted to the point E at which the stable and low NOx combustion can be effected. The F_1 diffusion combustion is shifted, in correspondence to the increase of the air A_1, from the point D to the point E which is nearer to the unstable range, and however, there arises no problem because the range of the stable fuel-air ratios is wider as compared with the F_2 premix combustion. Further, since the amount of the fuel corresponding to the shortage required for keeping the power constant is appropriated for the F_1 diffusion combustion zone, it is shifted from the point E to the point E' at which a more stable combustion can be effected.

In the way described above, it is possible to realize a stable and low NOx combustion even when the calorific value is changed.

In Figure 7, the abscissa represents the calorific value signal and the ordinate represents the IFC opening correction amount. The range of the fuel command signal is taken as parameter that is so set as being 1 between the points A and B, 2 between the points B and C and 3 between the point C and the point of the rated load, as shown in Figure 6, while giving consideration to the increase of the sensitivity in the amount of correction for the flow rate of air attributable to the increase of the flow rate of the fuel.

Figure 8 is a control block diagram of the present invention. The IFC opening setting device 7 is the conventional setting device of Figure 4 and the IFC opening correcting device 10 is the one shown in Figure 7. In order to limit the IFC opening/closing speed, the signal is sent to the adder 11 through a rate limit 14 provided additionally. The signal is passed through a limiter 15 before it serves as the IFC control signal so as to protect the issue of such command that is beyond the IFC full open position.

According to the present invention, it is possible to prevent the blowout and backfire of the premix flame, increase of the NOx concentration and the like which are caused due to the change of the calorific value of the fuel, and it is also possible to improve the reliability on the treatment of BOG gas in the LNG firing combined cycle power plant.

Claims

1. A method for controlling a combustion apparatus which has a premix burner and a diffusion burner, said method comprising the steps of:

   controlling an amount of air supplied to the premix burner in accordance with a calorie of fuel to be supplied to said apparatus so as to achieve a low NOx within a range in which the premix burner effects a stable combustion; and

   supplementing a change of a power of the combustion apparatus attributable to the control of the amount of air supplied to the premix burner by controlling an amount of the fuel supplied to the diffusion burner.

2. A method for controlling a combustion apparatus which has a premix burner and a diffusion burner, said method comprising the steps of:

   controlling, when a calorie of fuel to be supplied to the premix burner is changed, an amount of air supplied to the premix burner in accordance with the amount of change of the calorie so as to achieve a low NOx within a range of stable combustion; and

   supplementing a change of a power of the combustion apparatus attributable to the change of the calorie of the fuel by controlling an amount of the fuel supplied to the diffusion burner.

3. A method for controlling a combustion apparatus which has a premix burner and a diffusion burner which are both supplied with fuel from a same fuel supply system, said method comprising the steps of:

   controlling, when a calorie of the fuel supplied is changed, a fuel-air ratio in the premix burner in accordance with the amount of change of the calorie so as to achieve a low NOx within a range in which the premix burner effects a stable combustion; and

   supplementing a change of a power of the combustion apparatus attributable to the change of the calorie of the fuel by controlling an amount of the fuel supplied to the diffusion burner.

4. A method for controlling a combustion apparatus which has a premix burner and a diffusion burner which are both supplied with fuel from a same fuel supply system, said method comprising the steps of:

   monitoring a calorific value possessed by the fuel;

   controlling a fuel-air ratio of the premix

burner in response to a detection of a change of the calorific value during the monitoring so as to allow the premix burner to effect a combustion within a range of stable combustion; and

supplementing a change of a power of the combustion apparatus attributable to the change of the calorific value of the fuel by controlling an amount of the fuel supplied to the diffusion burner.

5. A method for controlling a combustion apparatus which comprises a premix burner and a diffusion burner both of which effect combustion of same kind of fuel, said method comprising the steps of:

monitoring a calorific value possessed by the fuel;

controlling, when it is detected by this monitoring that the fuel supplied possesses a different calorific value, a fuel-air ratio of the premix burner in accordance with the change of the calorific value so as to be in a range in which the combustion is effected in a stabilized manner while achieving a low NOx; and

supplementing a change of a power of the combustion apparatus attributable to the change of the calorific value of the fuel by controlling an amount of the fuel supplied to the diffusion burner.

6. A method for controlling a combustion apparatus which has a premix burner and a diffusion burner both of which effect combustion of same kind of fuel, said method comprising the steps of:

monitoring a calorific value possessed by the fuel;

controlling, when it is detected by this monitoring that the fuel supplied possesses a different calorific value, an amount of air supplied to the premix burner in accordance with the change of the calorific value so as to allow the premix burner to effect a stable combustion while achieving a low NOx; and

supplementing a change of a power of the combustion apparatus attributable to the change of the calorific value of the fuel by controlling an amount of the fuel supplied to the diffusion burner.

7. A method for controlling a combustion apparatus which has a premix burner and a diffusion burner which are both supplied with fuel from a same fuel supply system with amounts of fuel and air supplied thereto being controlled in accordance with a load of the combustion apparatus, said method comprising the steps of:

monitoring a calorific value possessed by the fuel;

controlling, when it is detected by this monitoring that the fuel supplied possesses a different calorific value, an amount of air supplied to the premix burner in accordance with the change of the calorific value so as to allow the premix burner to effect a stable combustion while achieving a low NOx; and

supplementing a change of a power of the combustion apparatus attributable to the change of the calorific value of the fuel by controlling an amount of the fuel supplied to the diffusion burner.

8. A method for controlling a combustion apparatus which has a premix burner and a diffusion burner, said method comprising the steps of:

controlling, when a calorie of fuel to be supplied to the premix burner is changed, an amount of air supplied to the premix burner so as to allow the premix burner to effect a low NOx combustion within a range of stable combustion; and

supplementing a change of a power of the combustion apparatus attributable to the change of the calorie of the fuel by controlling an amount of the fuel supplied to the diffusion burner.

9. A combustion apparatus which has a premix burner and a diffusion burner, said apparatus comprising:

a calorific value measuring device for measuring a calorific value of fuel to be supplied to the combustion apparatus;

a control device for controlling an amount of air supplied to the premix burner in accordance with a detection value of the calorific value measuring device so as to allow the premix burner to effect a low NOx combustion within a range of stable combustion; and

another control device for controlling an amount of fuel supplied to the diffusion burner so as to supplement a change of a power of the combustion apparatus attributable to the change of said calorific value.

10. A combustion apparatus which has a diffusion burner and a premix burner and in which an air supply regulating device for regulating an amount of air supplied is provided in an air supply system for the premix burner, said apparatus comprising:

a fuel composition monitoring device provided in a fuel supply system for the premix burner for measuring a calorific value possessed by a fuel supplied and for issuing a

command signal in accordance with the calorific value thus measured;

a control device disposed in the air supply regulating device of the premix burner for receiving the command signal and controlling in accordance with this command signal the air supply regulating device so as to determine an amount of air supplied that allows the premix burner to effect combustion within a stable range while achieving a low NOx; and

a fuel control device disposed in a fuel supply system for the diffusion burner for controlling fuel to be supplied to the diffusion burner so as to supplement a change of a power of the combustion apparatus attributable to the change of the calorific value.

11. A combustion apparatus which has a diffusion burner and a premix burner and in which an air supply regulating device for regulating an amount of air supplied is provided in an air supply system for the premix burner, said apparatus comprising:

a fuel composition monitoring device provided in a fuel supply system for the premix burner for measuring a calorie possessed by a fuel supplied and issue a signal corresponding to the calorie thus measured;

a control device disposed in the air supply regulating device for the premix burner for receiving the signal and for controlling in accordance with this signal the air supply regulating device so as to determine an amount of air supplied that allows the premix burner to effect combustion within a stable range while achieving a low NOx; and

a fuel control device disposed in a fuel supply system for the diffusion burner for controlling a fuel supplied so as to supplement a change of a power of the combustion apparatus attributable to the change of the calorie.

FIG. 1

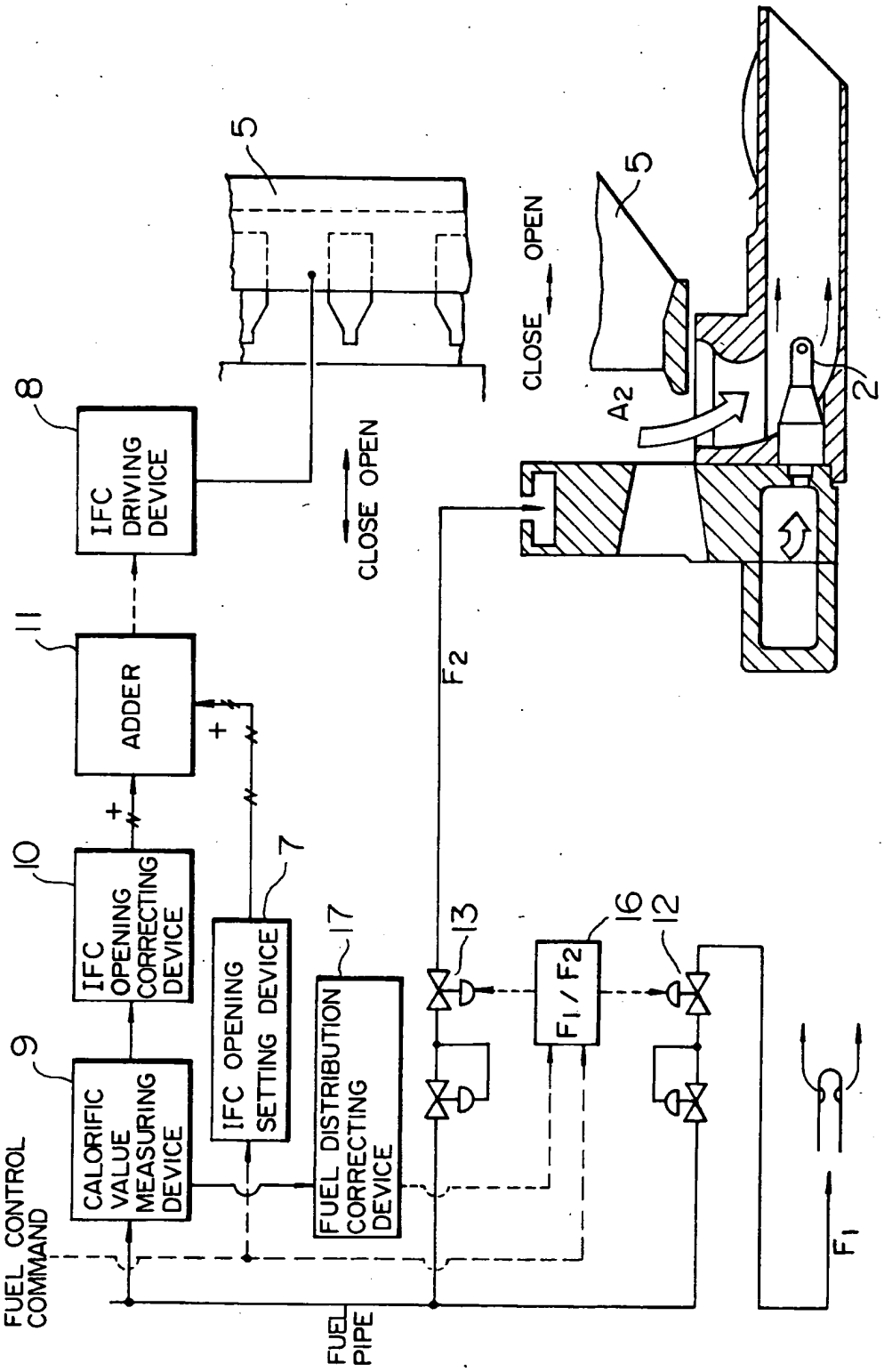

5
8
IFC DRIVING DEVICE
CLOSE OPEN
11
ADDER
+
+
10
IFC OPENING CORRECTING DEVICE
7
IFC OPENING SETTING DEVICE
9
CALORIFIC VALUE MEASURING DEVICE
17
FUEL DISTRIBUTION CORRECTING DEVICE
FUEL CONTROL COMMAND
FUEL PIPE
13
16
12
F1 / F2
F1
F2
CLOSE OPEN
5
A2
2

FIG.2

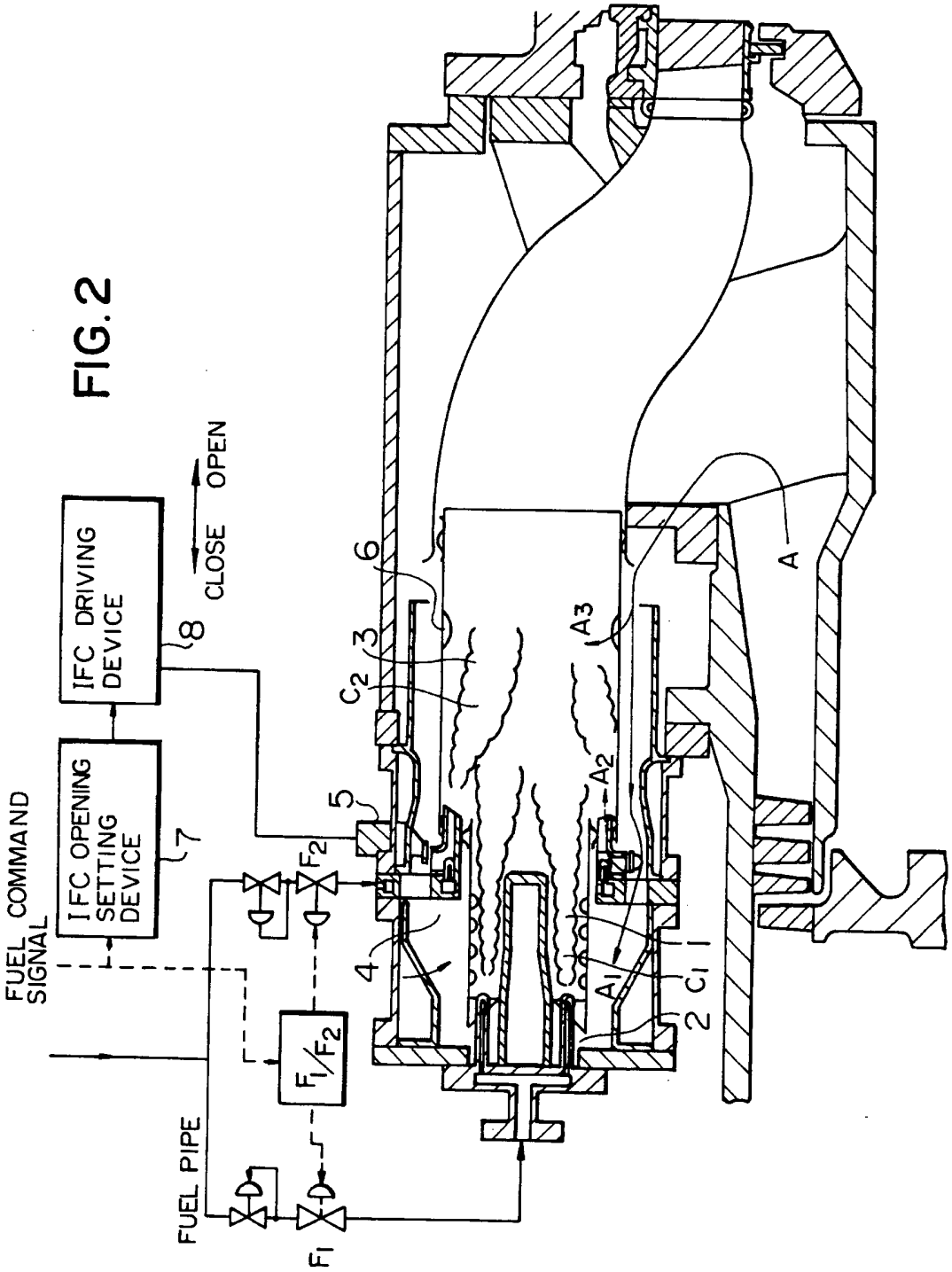

FUEL COMMAND SIGNAL
IFC OPENING SETTING DEVICE
IFC DRIVING DEVICE
CLOSE
OPEN
FUEL PIPE
F1
F2
F1/F2
A
A1
A2
A3
C1
C2
2
3
4
5
6
7
8

FIG. 3

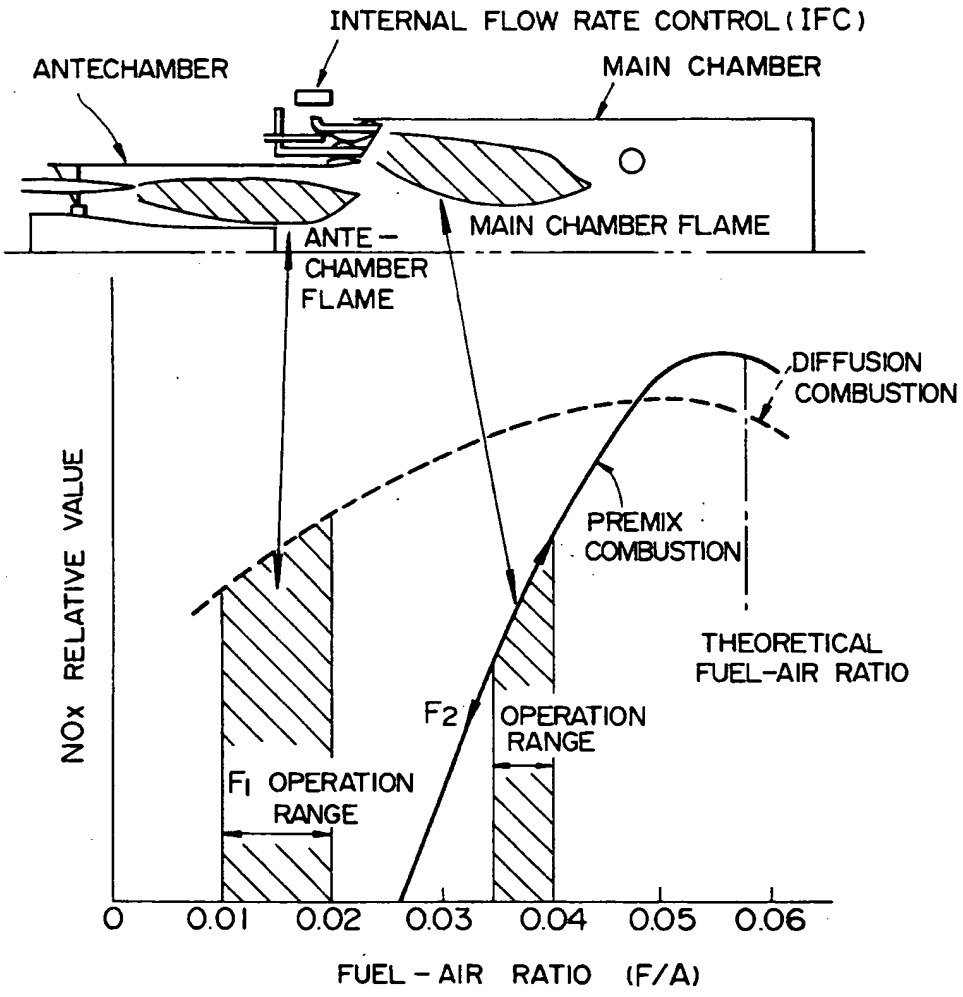

INTERNAL FLOW RATE CONTROL (IFC)
ANTECHAMBER
MAIN CHAMBER
MAIN CHAMBER FLAME
ANTE-CHAMBER FLAME
DIFFUSION COMBUSTION
PREMIX COMBUSTION
THEORETICAL FUEL-AIR RATIO
F2 OPERATION RANGE
F1 OPERATION RANGE
NOx RELATIVE VALUE
0
0.01
0.02
0.03
0.04
0.05
0.06
FUEL-AIR RATIO (F/A)

FIG. 4

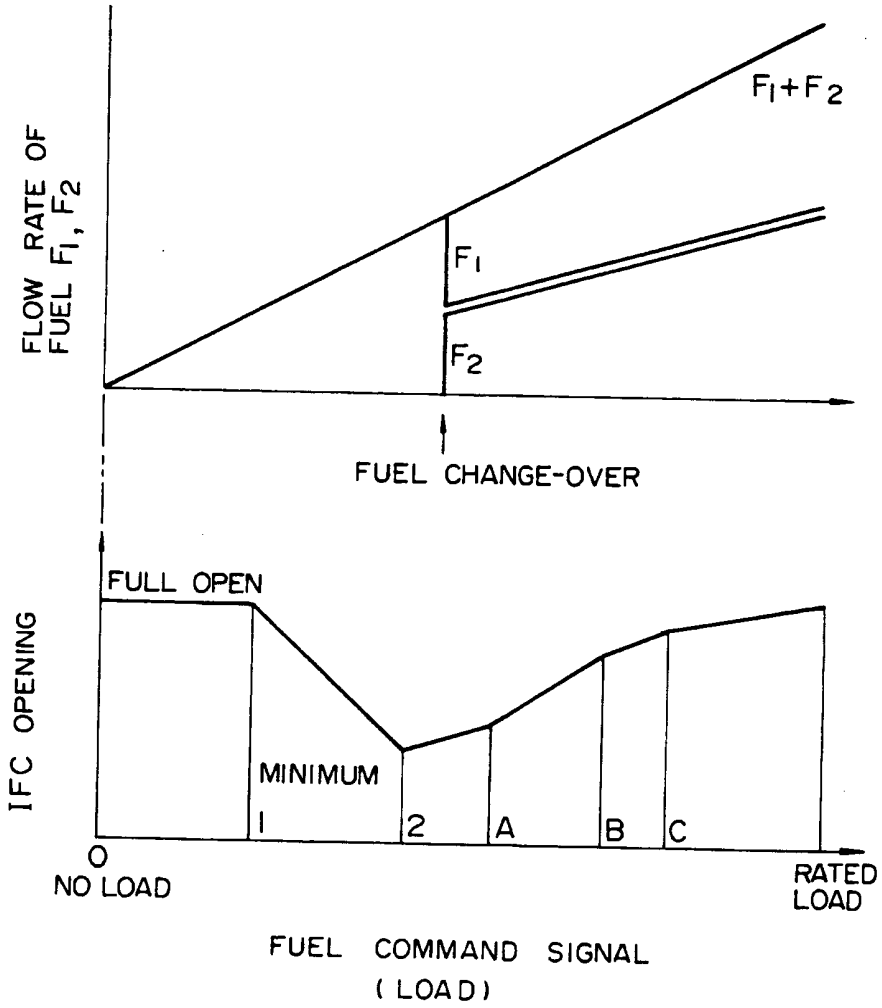

FLOW RATE OF FUEL F1, F2
F1+F2
F1
F2
FUEL CHANGE-OVER
IFC OPENING
FULL OPEN
MINIMUM
1
2
A
B
C
0
NO LOAD
RATED LOAD
FUEL COMMAND SIGNAL
(LOAD)

FIG. 5

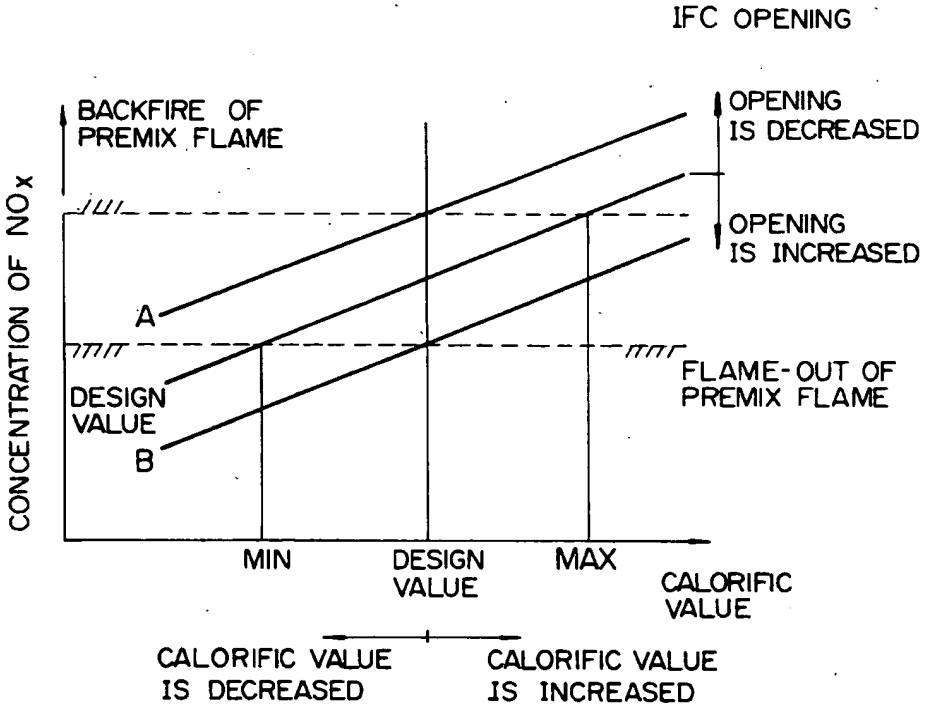

IFC OPENING
BACKFIRE OF PREMIX FLAME
CONCENTRATION OF NOx
OPENING IS DECREASED
OPENING IS INCREASED
A
DESIGN VALUE
B
FLAME-OUT OF PREMIX FLAME
MIN
DESIGN VALUE
MAX
CALORIFIC VALUE
CALORIFIC VALUE IS DECREASED
CALORIFIC VALUE IS INCREASED

FIG. 6

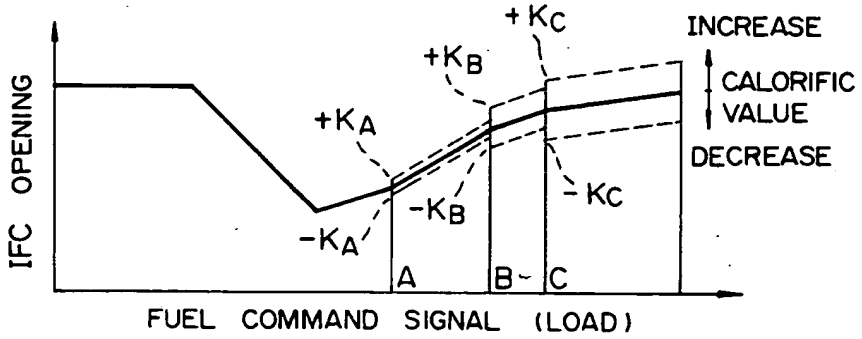

IFC OPENING
+KC
+KB
+KA
INCREASE
CALORIFIC VALUE
DECREASE
-KA
-KB
-KC
A
B
C
FUEL COMMAND SIGNAL (LOAD)

FIG.7

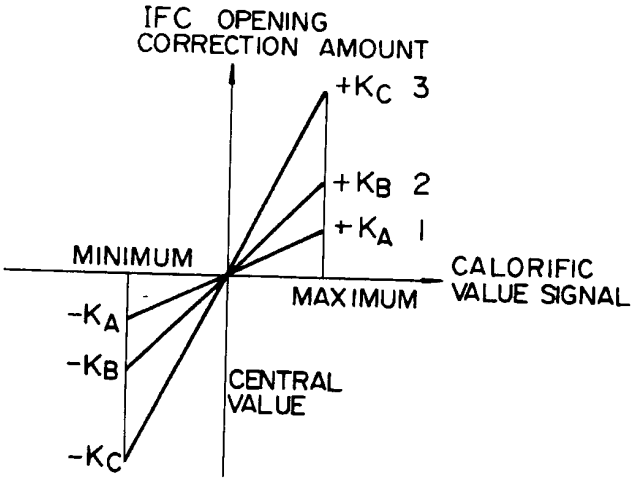

IFC OPENING
CORRECTION AMOUNT
+Kc 3
+KB 2
+KA 1
MINIMUM
MAXIMUM
CALORIFIC
VALUE SIGNAL
-KA
-KB
-Kc
CENTRAL
VALUE

FIG.8

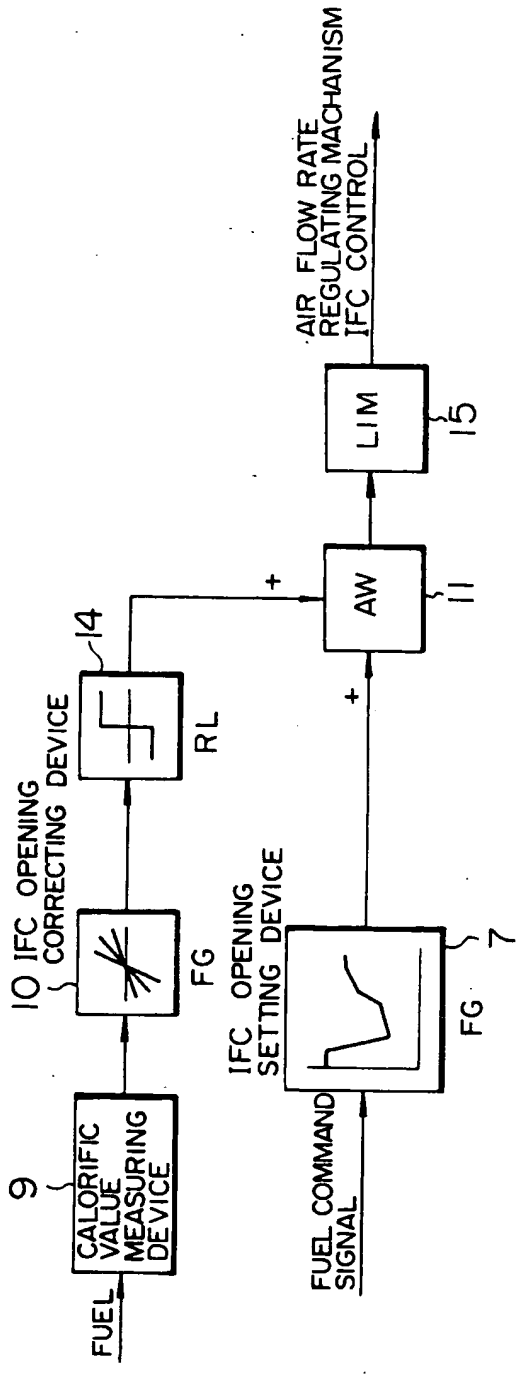

FUEL
9
CALORIFIC VALUE MEASURING DEVICE
10 IFC OPENING CORRECTING DEVICE
FG
14
RL
+
AW
11
+
LIM
15
AIR FLOW RATE REGULATING MACHANISM IFC CONTROL
IFC OPENING SETTING DEVICE
FG
7
FUEL COMMAND SIGNAL

FIG. 9

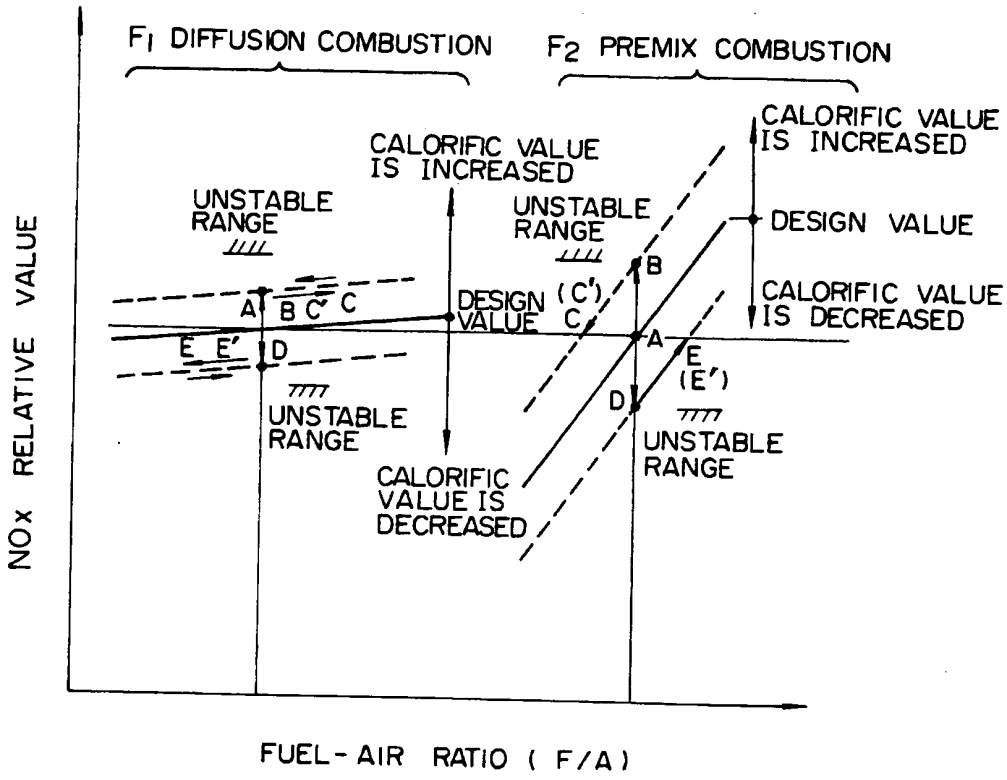
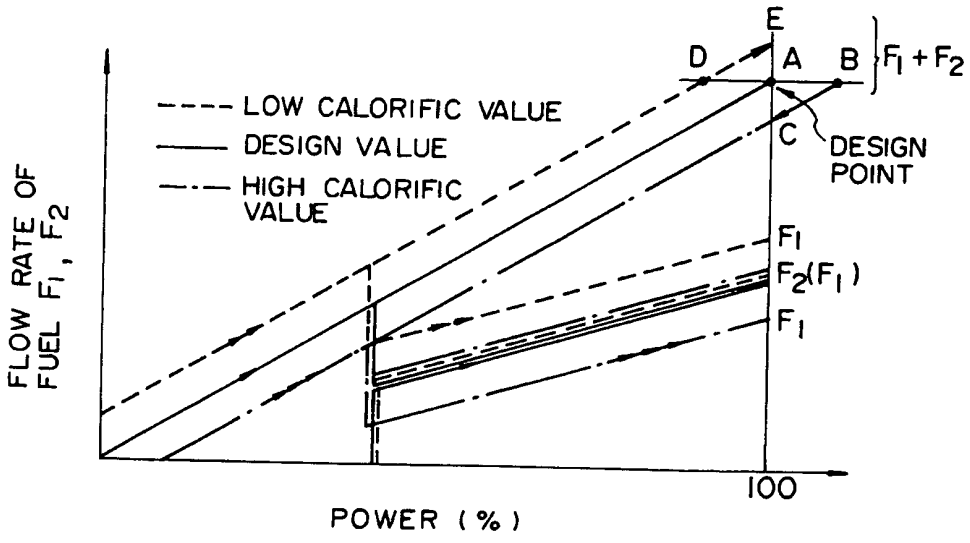

F1 DIFFUSION COMBUSTION
F2 PREMIX COMBUSTION
CALORIFIC VALUE IS INCREASED
UNSTABLE RANGE
UNSTABLE RANGE
CALORIFIC VALUE IS INCREASED
DESIGN VALUE
CALORIFIC VALUE IS DECREASED
A B C' C
DESIGN VALUE
(C')
C
B
A
E E'
D
E
(E')
D
UNSTABLE RANGE
UNSTABLE RANGE
CALORIFIC VALUE IS DECREASED
NOx RELATIVE VALUE
FUEL-AIR RATIO (F/A)

FIG. 10


E
D
A
B
F1 + F2
LOW CALORIFIC VALUE
DESIGN VALUE
HIGH CALORIFIC VALUE
C
DESIGN POINT
F1
F2(F1)
F1
FLOW RATE OF FUEL F1, F2
100
POWER (%)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 10 2875

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 055 852 (HITACHI LTD.) * abstract * * page 8, line 16 - line 21 * * page 9, line 3 - line 10 *	1-10	F23R3/26 F02C9/40
A	US-A-3 766 734 (R.M.JONES) * abstract * * column 1, line 23 - line 36 * * figure 1 *	1-10	
A	WO-A-8 808 075 (SOLAR TURBINES INC.) * abstract *	1	
A	EP-A-0 222 173 (HITACHI LTD.)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F02C F23R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	03 JUNE 1992	CRIADO Y JIMENEZ, F.

CATEGORY OF CITED DOCUMENTS

- X : particularly relevant if taken alone
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